U.S. ARMY-BAYLOR UNIVERSITY GRADUATE PROGRAM

IN HEALTH CARE ADMINISTRATION

GRADUATE MANAGEMENT PROJECT:

PHYSICAL TRAINING IN AN INFANTRY TRAINING BATTALION

SUBMITTED

IN PARTIAL FULFILLMENT OF REQUIREMENTS

BY

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NAVAL HOSPITAL CAMP LEJEUNE

MAY 1996

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	MAY 1996	FINAL REPORT (07-95 TO 05-96)

4. TITLE AND SUBTITLE
PHYSICAL TRAINING IN AN INFANTRY TRAINING BATTALION

5. FUNDING NUMBERS

6. AUTHOR(S)
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NURSE CORPS, USN

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NAVAL HOSPITAL
CAMP LEJEUNE, NC

8. PERFORMING ORGANIZATION REPORT NUMBER
32d-96

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
BLDG 2841 MCCS HRA US ARMY BAYLOR PGM IN HCA
3151 SCOTT ROAD
FORT SAM HOUSTON TEXAS 78234-6135

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Two Infantry Training Battalions (ITB) were used to evaluate a physical training (PT) program developed by the Naval Hospital Camp Lejeune Sports Medicine Department. After attending a three day seminar on PT concepts, intervention group squad leaders prepared and implemented a Sports medicine approved PT schedule. The control company followed the standard SOI PT guidelines.

Squad leader PT knowledge increased significantly following training. Intervention group student Marines suffered significantly fewer musculoskeletal overuse injuries and spent fewer days on limited duty than their control group peers. A greater portion of student Marines following the standard PT program, however, completed their company's 12 mile hump.

Military leaders, line and medical, must work together to develop methods of enhancing medical readiness. Proposed solutions must be carefully evaluated and changes implemented when indicated. The PT program designed for ITB is scientifically based, demonstrates good outcomes, and appears applicable to both military training and operational environments. The joint effort undertaken between Sports Medicine and SOI has produced tangible results for SOI and has generated greater interest in a spirit of cooperation in the Camp Lejeune area that will lead to future endeavors to keep troops injury free and readily deployable.

14. SUBJECT TERMS	15. NUMBER OF PAGES
SPORTS MEDICINE; OVERUSE INJURIES; MUSCULOSKELETAL INJURIES	35
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
N/A	N/A	N/A	UL

ACKNOWLEDGMENTS

I would like to thank Dr. Edwin Henrie and the entire Sports Medicine staff for including me in their School of Infantry Physical Training project. Special thanks are also extended to CAPT J. P. Van Landingham for his ongoing mentorship and to my husband, Carey T. Boyle, for his steady patience and support of my academic and professional pursuits.

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PHYSICAL TRAINING IN AN INFANTRY TRAINING BATTALION

Two Infantry Training Battalions (ITB) were used to evaluate a new physical training (PT) program developed by the Naval Hospital Camp Lejeune Sports Medicine Department: the control group Bravo company (n=354) and the intervention group Charlie company (n=353). Charlie company squad leader PT knowledge, measured on a pre- and post test, increased significantly following a 3 day seminar, correlated $t(df=8) = 3.4$, $n = 9$. Charlie company followed the pilot PT program; Bravo company followed the standard PT program. Bravo experienced a 0.16 injury rate and Charlie a 0.06 injury rate. The 0.10 difference was significant, Chi Square (1) = 18.15, p=0.05. Bravo totaled 450 musculoskeletal overuse limited duty days and Charlie totaled 128 days. Fisher's t for unequal groups demonstrated a significant between group difference in limited duty days, $t(df = 705) = 4.31$, $p = 0.05$. To evaluate physical fitness associated with the new PT program, 12 mile hump results for the two companies were compared. Bravo enjoyed a 0.996 completion rate (253 of 254) and Charlie a 0.944 completion rate (305 of 323). The difference in hump completion was noted to be significant based on Chi Square analysis, Chi Square (1) = 11.98, $p = 0.05$.

Military leaders, line and medical, must work together to develop methods of enhancing medical readiness. Proposed solutions must be carefully evaluated and changes implemented when indicated. The PT program designed for ITB is scientifically based, demonstrates good outcomes, and appears applicable to both military training and operational environments. The joint effort undertaken between Sports Medicine and SOI has not only produced tangible results for SOI, but has also generated greater interest in a spirit of cooperation in the Camp Lejeune area that will lead to future endeavors to keep troops injury free and readily deployable.

Introduction

The Marine Corps requires the right number of well trained, physically fit troops in order to perform its mission. Many consider the Marines the world's elite fighting force: "available world wide on a moment's notice." Non-end of active service (EAS) attrition, the early release of military members from active duty, however, hinders Marine Corps strategic planning and readiness initiatives, reduces unit productivity, and is costly.

Three categories of non-EAS attrition exist: medical, administrative, and punitive. The large medical contribution to non-EAS attrition is troublesome to Marine leadership. Medically related non-EAS attrition within the first service year is of particular concern to Marine Corps leaders. To recruit and train a Marine is costly. The Marine Corps' 1996 fiscal year budget for active duty and reserve advertising and recruiting is approximately 65 million dollars (Burton 1996). The variable training cost of a Marine Infantryman from recruit training through the School of Infantry is $409 (Cline 1995). Each subsequent level of training adds to the cost of developing a qualified Marine. Non-EAS attrition prevents the Marine Corps from obtaining the desired return on a expensive investment. Military downsizing, a shrinking applicant pool, and funding constraints render non-EAS attrition an important improvement opportunity.

Navy Medicine, the Marine Corps' primary care provider, is intimately involved in efforts to reduce medically related non-EAS attrition. Injury prevention, and/or its early identification and rehabilitation is a fundamental support activity, as well as a method of increasing resource efficiencies in a managed care environment. Medically related non-EAS attrition is now a top agenda item for both the Marine Corps and Navy Medicine.

Navy Sports Medicine specialists are involved in efforts to identify improvement opportunities and develop solutions to decrease the disabling musculoskeletal injuries experienced by Marines during training and operations. Sports Medicine strives to achieve physical fitness through scientifically based training which emphasizes strengthening, conditioning, and flexibility. Sports Medicine focuses on primary education, injury prevention, early injury detection, and rehabilitation. The Marines are willing to listen to these specialists, but desire confirmation that suggested solutions are effective. This study evaluates a physical training program designed by a Naval Hospital Sports Medicine Department and piloted at a Marine Corps training command.

Literature Review

In a 1994 article, Eathorne described musculoskeletal complaints as the "commonest problems presenting in a sports medicine setting." Injuries in this category include: pain, swelling, aching, stiffness, loss of motion, or impairment of function resulting from acute or chronic sports-related injury to skeletal, joint, or muscular structures (Eathorne 1994). Stacy et al. categorized such injuries as precipitated by overuse or trauma. They described overuse injuries as the result of recurring stress, and traumatic injuries as those occurring "instantaneously" in a specific incident (Stacy and Hungerford 1994). Overuse injuries can be debilitating and their prevention is of particular concern to Marine leaders and Navy Medical providers.

The military's interest in physical training, fitness, and injury prevention is not new. Musculoskeletal injuries, particularly those of the lower extremity linked to overuse, have

long been recognized as costly and detrimental to troop productivity. Numerous investigators have described the magnitude of overuse injuries and sought to identify those factors associated with injury which may be manipulated. Researchers estimated the 1993 cost of musculoskeletal injuries at Marine Corps Recruit Depot, San Diego at 16.5 million dollars and 53,600 lost training days (Brodine and Shaffer 1995).

Researchers credit Breithaup, a Prussian military surgeon, with first linking the incidence of lower extremity stress fractures to extended marching in 1885 (Giladi et al. 1985; Scully and Besterman 1982; Pester and Smith 1991).

In 1983, Jones, of the U.S. Army Research Institute of Environmental Medicine, reviewed the military experience with lower extremity overuse injuries. He reported a 62% injury rate among female Army recruits, a 26% rate among male Army recruits, and a 37% rate among male Marine recruits. Jones identified eight factors in the development of overuse injuries: prior physical condition, physical anomalies, body weight, previous injury, gender, training surface, equipment such as footwear, and training techniques. He described foot wear and training techniques as the "most amenable to manipulation." Expressing optimism over field investigations, Jones cautioned those involved to carefully control their studies in order to verify prevention techniques (Jones 1983).

Scully and Besterman identified continued high magnitude load bearing as the key contributor to stress fractures in 1982. They also described the bone's physiologic response to this stressor. Bone, they noted, is a "dynamic, living tissue" capable of withstanding load bearing stress up to a critical threshold at which point bone damage occurs. If the stress is removed at the threshold, a repair process of osteon maturation

and periosteal new bone formation leads to a stronger, healthier bone. If, on the other hand, load bearing and damage continues past the critical point, a stress fracture results. Based on studies documenting the incidence of stress fractures, Scully and Besterman identified the third week of Army basic training as the critical period for the development of stress fractures. To combat the risk of stress fractures, they recommended curtailing physical training during the third week of basic training. Fort Knox leaders investigated this suggestion in the mid-1970s. A control group of 440 trainees underwent the standard physical training program, while a test group of 440 followed a modified schedule with restricted running, jumping, and double timing during the third week. Statistical analysis was not reported, yet the project was declared successful based on the 3.2% lower injury rate in the test group and "equal" physical fitness test scores between the two groups. Fort Bliss researchers also reported success with third week activity restrictions, but did not relate if the reduction in injury was significant (Scully and Besterman 1982).

Combat boots came under close scrutiny as a source of lower extremity injuries in the early 1980s. Linking continued strain upon bones, connective tissues, ligaments, and fascia of the foot to combat boot design, deMoya compared ground reaction forces between the standard military boot and running shoes and between five different boot styles using 12 male and 5 female officer cadets. Based on analysis of variance of three component measurements (impact response, flexibility, and change at impact), the running shoe was found to be significantly better than the standard combat boot, and the Modified Standard boot significantly superior to the Corocoran boot. Although deMoya recognized a small sample size and noncombat environmental conditions as study limitations, he

admonished Army leaders to implement training in running shoes wherever possible. He cautioned that training in boots strictly because running shoes will not be worn during combat may result in injuries which "prohibit commanders from taking an effective force to war" (deMoya 1992). In spite of these findings, there are still those who adhere to the tradition of training in boots, without socks, in order to "toughen the foot" for the operational environment (Smith 1995).

The New Zealand Army evaluated a physical training running shoe policy and the gradual introduction of combat boots among 316 recruits in 1984. Researchers described a 23.5% injury reduction and a 53.9% reduction in work time lost secondary to injury, but did not provide measures of significance. The New Zealand researchers also commented on the cyclic nature of overuse injuries and supported the notion of scaling back training in the third training week (Stacy and Hungerford 1984).

In 1985 Giladi et al. acknowledged the osteonization process described by Scully and Besterman, but called for increased consideration of the cumulative effects of physical training stresses. To evaluate the effects of cumulative stress, they conducted Chi Square analysis on stress fracture occurrence in two Israeli basic training groups; one following the standard training schedule, and the other with less frequent and more gradually introduced training. Giladi et al. found no significant differences in overall injury between the two groups and concluded that gradual training modifications did not prevent stress induced injuries, they only delayed the onset of injury (Giladi et al. 1985).

Noting poor study controls, Messier and Pittala criticized studies which described improper training techniques, poor equipment, and biomechanical/ anthropometric

abnormalities as key factors in overuse injuries. They used discriminant function analysis, to compare a non-injured control group with three injury specific groups and identified significant biomechanical differences between the control group and the shin splint group, and significant differences in anthropometric variables and training data such as hill, road, or trail running between the control and plantar fasciitis groups. They reported no significant differences between groups in the areas of training pace, weekly mileage, and years running (Messier and Pittala 1988).

In 1991 Meeuwisse also called for well controlled injured/non-injured group studies. He specifically recommended studies based on regression analysis to identify those internal factors predictive of overuse injuries. Meeuwisse defined internal factors as "those that are a part of the [individual] themselves," including biomechanics, fatigue, and conditioning. Programs designed to prevent injuries, he noted, must be based on sound analysis to confirm effectiveness (Meeuwisse 1991).

Jones et al. focused on intrinsic risk factors in 1991 when they used questionnaires, anthropometric measures, physical fitness testing scores, and injury data to evaluate 391 Army basic trainees. They identified several significant intrinsic risk factors: female gender, low levels of running performance, low levels of previous physical activity and high body mass index for men, and short stature in women. Based on the "similarity and overlapping nature of the trends," Bruce et al. described physical fitness as the "underlying" risk factor. They concluded by calling for additional multi-variate studies and advised future researchers to also consider extrinsic factors related to injury, including "the amount and types of exercise and physical activity, the intensity of training, and the personal equipment used"(Jones, Bovee, Harris, and Cowan 1993).

Fort Dix researchers reported a 0.96% overall incidence of stress fractures after monitoring 109,296 Army basic trainees over a four year period in the late 1980s. They then modified the training program, eliminating high impact activities during "high risk" weeks, and observed a 12.73% reduction in the incidence of stress fractures. Researchers analyzing this change, however, did not report results of statistical evaluation (Pester and Smith 1991).

Citing contradictory evidence regarding the utility of warm-up, cool-down, and stretching exercises in preventing lower extremity running injuries, van Mechelen et al. investigated knowledge of and attitude toward these topics, and injury rates. A 167 member control group and a 159 member intervention group were matched for the variables age and weekly running distance. Over a 16 week period both groups recorded daily running distance and injuries. The intervention group attended a seminar on a standardized warm-up, cool-down, and stretching program and recorded compliance with the standardized program over the 16 week period. At the end of 16 weeks, participants completed a questionnaire on the intervention topics, and inter-group questionnaire results and injury rates were compared. Although intervention group members scored significantly higher on the questionnaire, they did not experience a significantly lower rate of injury. Noting that all participants used "some form" of warm-up, cool-down, or stretching exercise, van Mechelen et al. advised emphasis on early detection and treatment of overuse injuries, rather than focusing on education programs geared toward preventing them (van Mechelen, Hlobil, Kemper, Voorn, and de Jongh 1993). Interestingly, van Mechelen's group did not explore the possibility of a Hawthorne effect as influencing

participant exercise habits, nor did they investigate where or how the control group had learned about these exercises. Despite their conclusions, education programs on warm-up, cool-down, and stretching exercises continue to receive support as a method of preventing exercise related injuries.

Military leaders concerned about attrition secondary to preventable injuries turn to Navy Medicine for help in avoiding "self inflicted" exercise related injuries. Proposed solutions, however, must be "doable" in the operational setting and not detract from military requirements. To be fully implemented solutions must be designed around militarily defined readiness requirements.

Some Marine leaders are hesitant to change physical training methods (Smith 1995). They fear modifications to traditional training programs will result in a Marine ill equipped to overcome the physical and emotional challenges encountered in an operational setting. Specialty school leaders emphasize the fact that their students are fully deployable on graduation, and cite examples of students who deployed to extremely hostile environments within hours of graduation (Smith 1995). Henrie, a physician deployed with Marines during Operation Dessert Shield/Dessert Storm acknowledges readiness concerns, yet contends the "rifleman athlete's" readiness may be enhanced through training specifically targeted to prepare for three energy requirements: sprinting, short distance runs, and long distance runs (Henrie 1991).

Project Outline, Operational Definitions, and Hypotheses

During a September 1995 presentation to the Marine Corps Base Camp Lejeune School of Infantry (SOI) and Naval Hospital Commanding Officers, CDR Edwin Henrie, the Sports Medicine Department Head, outlined three essential components of a fitness program: strength, flexibility, and endurance. He cautioned against "too much, too soon, too fast" and noted intensity, duration, and frequency must be carefully manipulated to create a safe, effective training program. Henrie proposed a joint "Blue side/Green side" physical training initiative consisting of squad leader education and a highly structured physical training program for a test company within SOI's Infantry Training Battalion (ITB) (Henrie 1995).

The Sports Medicine Department expected to demonstrate a reduction in injuries, limited duty days, and training disenrollemnt secondary to musculoskeletal overuse injuries, without detracting from the Green side definition of physical fitness. The commands approved the proposal and agreed to work collaboratively to "make it happen."

ITB trains basic infantrymen for the following Military Occupational Specialties (MOS): rifleman, machine gunner, mortar-man, assault-man, and anti-tank guided missleman. ITB companies consist of approximately 350 students led by 11 - 12 squad leaders. MOS qualifications and physical training are both components of the 8 ½ week curriculum. The school strictly enforces MOS training components, but only suggests dates for company physical training (PT). Company PT is left to the squad leaders' discretion and is often "fit into" a rigorous MOS focused schedule (Zimmerman 1995).

ITB squad leaders lead and guide their company through training requirements. Squad leaders receive their assignment based on successful completion of past duty assignments and are randomly assigned to "next available billets." No formal instructor or PT training guidance is provided squad leaders, they carry out their responsibilities based on personal knowledge and previous experiences. Company squad leaders are assumed to be homogenous in training, experience, and instructional approach. Squad leader physical training knowledge is represented by the score on a 52 item test written and graded by local subject matter experts (appendix 1).

ITB students are male Marines who enter ITB following a 10 day boot leave period. ITB students are typically young, junior Marines and are considered a homogenous group. They are assigned to the next available company. A company may receive additional students during the initial training period, these students are known as "pick-ups." Students are identified by company group membership, Bravo or Charlie.

Musculoskeletal overuse injuries are non-acute and result from recurring stress vice trauma as described by Stacy in 1984. Student Marines are categorized as having received a musculoskeletal overuse injury, yes/no. All company Branch Clinic sick call and/or Sports Medicine Clinic visits are documented and categorized by a Sports Medicine physician for their relationship to musculoskeletal overuse (yes/no). Musculoskeletal overuse injuries may include: patellofemeroral pain syndrome, Achilles tendinitis, patellar tendinitis, iliotibial band friction syndrome, stress fractures, trochanteric bursitis, per anserinus tendinitis, plantar fasciitis, ankle injuries, and back pain.

ITB defines physical fitness as the ability of a Marine to "hump," and prides itself on the ability of students to complete a 12 mile hump prior to graduation. A hump is a 2.5

- 3 mile per hour walk/march in full combat gear. Combat gear includes boots, utilities, web gear, Alice packs, canteens, flak jackets, helmet, combat pack, gas mask, grenade, loaded individual weapons, M16, and a crew served weapon. Pieces of the crew served weapon are passed among 2 - 3 Marines from the weapons group. Squad leaders evaluate Marine students who experience difficulties, either physical and emotional, during the hump and encourage the student to continue whenever possible. If the squad leader judges the Marine incapable of continuing, the Marine "falls out" and is referred to accompanying medical personnel for evaluation and transport. Hump success requires the Marine to complete the walk/march, with his unit, under his own locomotion; he either succeeds or does not succeed.

Limited duty restricts the student Marine from participating in PT activities. The total number of limited duty days ordered for company students during the ITB training period, by a Sports Medicine or Branch Clinic provider and secondary to a musculoskeletal overuse injury, is calculated for each company. For student Marines reassigned to the Marines Awaiting Training (MAT) company secondary to a musculoskeletal injury, all limited duty days ordered prior to reassignment are included in the calculation of total company limited duty days. ITB students may be disenrolled for a variety of medical and non-medical reasons. Company disenrollments are categorized initially as medically related or not medically related. Medically related disenrollments are further categorized as secondary too, or not secondary to musculoskeletal overuse injuries. Students disenrolled are assigned to the MAT company to await a decision on continuation of training.

Naval Hospital Camp Lejeune and its Sports Medicine Department expected close scrutiny of this initiative and desired careful outcomes analysis. The purpose of this analysis was to evaluate the following hypotheses:

> H_1: SOI ITB squad leader physical training knowledge increases as a function of a formalized education program.
>
> H_2: SOI ITB company musculoskeletal overuse injuries are related to the type of PT program followed during training.
>
> H_3: SOI ITB company physical fitness is related to the type of PT program followed during training.
>
> H_4: SOI ITB company limited duty days secondary to musculoskeletal overuse injuries are related to the type of PT program followed during training.
>
> H_5: SOI ITB company disenrollment secondary to musculoskeletal overuse injuries is related to the type of PT program followed during training.

Research Design

Methods and Procedures

Two SOI ITB companies were used to evaluate the proposed PT initiative. Bravo Company served as the control group and Charlie Company as the intervention group. Bravo and Charlie Companies' start dates made them convenient evaluation groups. The students assigned to each company made up the sample for evaluating injuries and limited duty days. Bravo company started with 349 students and picked-up 5 for a total of 354 students. Charlie company had 353 students, 350 on day one plus 3 pick-ups.

A physical fitness training seminar was conducted for squad leaders assigned to Charlie company. The squad leaders served as the sample for evaluating the education

seminar. Prior to attending the seminar, squad leaders completed a 52 item knowledge based pre-test. Resident subject matter experts designed the test and conducted the seminar (appendix 1). The 3 day physical training seminar used both didactic and hands on training methods and covered a variety of topics (appendix 2). Squad leaders were given an instruction booklet outlining course material (appendix 3). On the last seminar day squad leaders took a post-test identical to the pre-test. The test was graded by course instructors.

ITB's standard "suggested" PT schedule is provided as appendix 4. As noted previously, actual company PT is left to squad leader discretion; no record of Bravo Company PT was kept. Charlie Company adhered to a detailed PT schedule which was planned in advance by squad leaders after attending the training seminar. The Sports Medicine Department Head reviewed and approved Charlie Company's PT schedule. The first weeks of Charlie Company's daily regimen is outlined in appendix 5. The Sports Medicine Department Head attended various training sessions to answer questions and identify implementation issues.

The Camp Geiger Branch Medical Clinic maintains all ITB student health records and provides routine health care. Students typically enter the health care system by reporting for sick call. Occasionally, a student may experience health concerns after hours and report to the Naval Hospital's Emergency Department or After-Hours Sick Call. If the event is considered non-acute, the student is instructed to report to sick call the next day. As musculoskeletal overuse injuries are considered non-acute, it was assumed that these injuries were all evaluated in the Branch Clinic. Sick call patients may be evaluated

and treated by a Branch Clinic medical provider, or evaluated and referred for a specialty consult. Non-acute musculoskeletal complaints requiring further evaluation are referred to the Sports Medicine Clinic. A Sports Medicine physician conducted retrospective chart reviews to identify musculoskeletal injuries and their associated limited duty days for Bravo and Charlie Companies.

The SOI's administrative branch processes all company disenrollments and categorized ITB disenrollment from the test and control group as either medically or nonmedical related. Due to an administrative misunderstanding, further categorization of medical disenrollments was not possible.

All students assigned to Bravo or Charlie were expected to participate in their company's 12 mile hump. The number of student Marines starting the hump comprised the sample. Only those who completed the hump under their own locomotion were considered to have successfully finished the hump. Squad leaders identified the number who started and completed the hump.

Validity, Reliability, and Assumptions

The research design contained content validity based on Blue side/ Green side collaboration in defining outcomes, paired squad leader testing, resident expert participation, and professional categorization of injuries. Several confounding variables and reliability errors, however, were recognized as having the potential to influence results.

Individual differences and internal factors can influence outcomes, yet student Marines and squad leaders were considered homogenous. It was also assumed that Bravo company's interpretation of the suggested ITB PT program represented the PT conducted by all other ITB companies. For the test group, the new PT program meant longer days and additional "work" for both students and squad leaders. These hardships, coupled with skepticism voiced by several Charlie Company squad leaders about changing traditional training methods, may have influenced commitment to the new training program. Conducting a blind evaluation was not possible and squad leaders from either company, aware that a new PT program was being evaluated, may have intentionally or unintentionally, altered their training methods. The basis for determining company disenrollment and hump fallout is not always clear-cut; there are occasions when the decision to remove a Marine from the hump is based on the squad leader's "gut feeling" regarding the Marine's ability and motivation rather than on any formalized criteria. External factors, such as weather and equipment, are uncontrollable, and may have played a role in hump completion.

Ethical Considerations

Based on conversations with the Clinical Investigations and Research Division at Naval Medical Center Portsmouth, VA, this study was considered a statistical assessment of a proposed solution to an identified improvement opportunity (non-EAS attrition) (Slade 1995). No personalized subject information was collected and the project was not considered to involve "human use."

Statistical Analysis

To assess squad leader physical training knowledge, a t test for paired test observations was used. Chi Square analysis was used to evaluate injuries and hump completion. Fisher's t for unequal groups was used to evaluate limited duty days. Alpha was set at $p < 0.05$ for all statistical testing.

Results

Fourteen of the fifteen Charlie company squad leaders attended the physical trainer's education seminar. Nine attendees completed both the pre- and post- seminar test. Table 1 presents descriptive information regarding the group's test results. As expected, test scores increased following the education seminars, from an average score of 37 to an average score of 72. Scores ranged from 6 to 89 points on the pre-test and from 45 to 86 points on the post test. One squad leader's test score declined following the seminar and the highest post education score was lower than the highest pre-seminar test score.

Table 1. Squad Leader Physical Trainer Knowledge

Squad Leader	Pre-test Score	Post-test Score
1	34	76
2	6	46
3	68	45
4	89	86
5	30	84
6	8	79
7	46	83
8	32	64
9	18	86
Mean	37	72
Standard Deviation	13.75	16.55

A t test for paired test observations was used to evaluate changes in squad leader physical training knowledge. The pre- and post-test scores differences were found to be statistically significant at $t(df=8) = 3.4$ at the o.o1 level. This finding supports the hypothesized relationship between PT knowledge and topic specific education.

The control company, Bravo, started training 3 weeks prior to the Charlie test company. Seventy musculoskeletal overuse injuries were identified among 58 Bravo company student Marines. Twenty-five such injuries were identified among 22 Charlie company students. A list of the injuries classified as related to musculoskeletal overuse is provided in Table 2.

Table 2. Musculoskeletal Overuse Injuries

Injury (Diagnosis or Site)	Bravo	Charlie
Lower Back	11	6
Upper Back/Neck	3	0
Shoulders/Chest	4	3
Biceps Tendinitis	0	1
Quadriceps/Hamstrings	2	1
Knee	10	3
Patellofemoral Pain Syndrome	12	3
Stress Fracture (Tib/Fib)	1	0
Shin Splints	1	0
Gastrocnemius Strain/Pain	2	1
Osgoode Shalter Syndrome	1	0
Achilles Tendinitis	2	0
Ankle Strain/Sprain	3	3
Pes Planus Fasciitis	4	2
Feet Pain/Boot Stress	3	1
Metatarsal	5	0
Blisters/Cellulitis	5	1
Pes Cavus	1	0
Total Injuries	70	25
Students with Injury	58	22

Although some students were seen for more than one musculoskeletal injury, students were considered injured or non-injured; the number of student Marines diagnosed as having a musculoskeletal injury was used for statistical calculations.

Patellofemoral Pain Syndrome, lower back injuries, and knee injuries were the most common musculoskeletal overuse injuries experienced by Bravo students. For Charlie students, the most common injuries were lower back injuries, shoulder and chest injuries, patellofemoral pain syndrome and ankle injuries. Injuries were counted one time only, follow-up visits were excluded from calculations. Additional information describing Bravo and Charlie Companies' musculoskeletal injuries and musculoskeletal related limited duty days is presented in Tables 3 and 4.

Table 3. Bravo & Charlie Company Musculoskeletal Injuries

Classification	Bravo	Charlie	Total
Students with Injuries	58	22	80
Students without Injuries	296	331	627
Totals	354	353	707
Injury Rate	0.16	0.06	

Table 4. Bravo & Charlie Company Musculoskeletal Injury Related Limited Duty Days

	Total Students	Total Number Musculoskeletal Limited Duty Days	Mean Number Musculoskeletal Limited Duty Days	Standard Deviation	ESS
Bravo	354	450	1.27	4.86	8336.35 ESS1
Charlie	353	128	0.36	0.00	0.00 ESS2
					8336.35 ESS y.x
Total	707	578	0.82	3.88	10648.38 ESSy

The observed probability of musculoskeletal injury for Bravo Company students was 0.16 and the observed probability of musculoskeletal injury for Charlie Company students was 0.06, a 0.10 difference. Resulting Chi Square (1) = 18.15, p = 0.05 demonstrated a statistically significant difference between groups and supports the hypothesis that a company's musculoskeletal injury experience is related to the type of PT conducted.

There were 450 musculoskeletal injury related limited duty days ordered for Bravo Company students, an average of 1.27 limited duty days per student. In contrast, 128 musculoskeletal limited duty days were ordered for Charlie Company students, an average of 0.36 days per student. The total difference in musculoskeletal limited duty days was 322 days. The between group difference was noted to be statistically significant using Fisher's t for unequal groups; t(df=705) = 4.31 at p = 0.05. This finding suggests that the number of training days lost to injury may be related to the type of PT program followed.

As noted, it was not possible to evaluate disenrollment secondary to musculoskeletal injury. Bravo Company dropped 30 students (8%) during its training evolution, while Charlie Company dropped 32 students (9%). Seventeen Bravo Company drops were medically related, however the specific cause was not documented. In Charlie Company, 9 of 20 medical drops were secondary to an overuse injury.

As planned, each company scheduled a 12 mile hump. Bravo Company students participated in several shorter humps prior to the 12 mile hump. For Charlie company students, however, the 12 mile hump was their first hump experience. Descriptive information regarding the 12 mile hump is provided in Table 5.

Table 5. Twelve Mile Hump Descriptive Statistics

Classification	Bravo	Charlie	Total
Successful (complete)	253	305	577
Unsuccessful (drop)	1	18	19
Totals	254	323	577
Completion Rate	.996	.944	.967

Bravo Company started the 12 mile hump with 254 of its original 354 students. The observed probability for hump completion among Bravo Company students was 0.996, only 1 Bravo Company student was unable to complete the hump. Charlie Company started the hump with a greater number of its original student body, 323 of 353. Eighteen Charlie Company students were unable to complete the hump, a 0.944 completion probability. Chi Square analysis of hump completion demonstrated a significant difference between the two groups, Chi Square (1) = 11.98, p = .05. This finding supports hypothesis number three, a relationship exists between hump completion and the type of PT conducted.

Discussion

The results support three concepts: (1) squad leader knowledge increases with topic specific education, (2) a Sports Medicine structured PT program is associated with fewer musculoskeletal overuse injuries and fewer limited duty days secondary to such injuries, and (3) physical fitness, defined as successful hump completion, may be related to the type of PT program followed by an ITB training company.

Education

As noted, ITB squad leaders, tasked with providing physical training for their squad members, rely on their own past experiences/preferences and follow a loosely defined PT schedule. Squad leaders who attended a formal education seminar on the theories and concepts of physical training activities demonstrated increased topic specific knowledge. This result supports van Mechelen et al.'s finding that topic specific knowledge increases with education (1993). Great Lakes Recruit Training Command researchers also documented a significant increase in topic specific knowledge following a Healthy Back seminar (Woodruff, Conway Bradway 1994).

To increase the validity and reliability of the squad leader education evaluation, the accuracy of the test tool might be measured and the sample size increased. Consistency in test administration might also be considered. Pre-tests were self administered outside the classroom, while the post-test was administered in a more traditional classroom setting.

Follow-up testing might be used to evaluate long term gains in knowledge and the ability or willingness to put knowledge into practice. Program administrators might also include a test section on individual beliefs and attitudes in order to pinpoint squad leader concerns and/or interests regarding PT education and schedule revisions. Score distribution and squad leader comments regarding the project make an attitude assessment an attractive target for future evaluation.

To assess the ability or willingness of squad leaders to pass on lessons learned, the PT test could be administered to graduating squad members. A squad member knowledge test would provide useful insight into the military tradition of "see one, do one, teach one."

Injury and Limited Duty Days

The reduced probability of musculoskeletal overuse injury and associated limited duty days reinforces the conclusions of other researchers: musculoskeletal overuse injuries in the military training setting are associated with the type of PT conducted. These findings also advance Henry's rule of progressive overload: increase only one component at a time (intensity, duration, or frequency) and increase activity level by only 10% of the previous activity (Henrie and Tapp 1995). The piloted PT program closely adhered to this rule. Generalizations based on these results, however, should be made with caution. Bravo company training may not in fact represent all SOI PT programs.

In calculating injuries medical record reviewers noted that documentation practices occasionally made it difficult to distinctly label injuries and that in some cases patient disposition (return to duty versus limited duty) was not documented. Record abstraction might be improved by educating first line providers regarding the nature of the investigation on more than one occasion or by requesting that first line providers refer all suspected musculoskeletal overuse injuries to the Sports Medicine clinic. Tracking when injuries occur over the course of a training cycle might also assist program administrators in identifying high risk training periods and contribute to the growing body of epidemiological information on sports injuries (Jordaan and Schwellnus 1994; Meeuwisse 1991).

Physical Fitness/ Hump Completion

The significant difference in hump completion surprised Sports Medicine personnel. As noted previously, however, external factors may have influenced hump completion.

During a post graduation review of the PT project Charlie company squad leaders described preliminary humps as necessary for preparing the mind, the body, and the equipment for the rigorous 12 mile hump. On interview, several squad members attributed their hump fall out to equipment malfunction. Squad leaders described preparatory humps as an important phase in breaking in gear. Additional information might be gained by categorizing the reason a student Marine drops from the hump (fatigue, gear, injury, etc).

The study's design did not take into consideration any pre-hump company losses. One hundred Bravo company students did not start the 12 mile hump. Future evaluations might be improved by evaluating the number of starting or graduating students who successfully completed the 12 mile hump. Of the 354 original Bravo company students 253 completed the hump, 71.5%. More Charlie company students completed the hump, 293 of the original 353 or 83%.

External factors may also influence hump success. Some external factors are controllable, others are not. Charlie company conducted its 12 mile hump following the 96 hour Thanksgiving special liberty. Charlie Marines also started the hump earlier in the day than usual. The designed study did not control for squad leader bias against PT program changes which may have influenced their assessment of student Marines. Several Charlie company student Marines reported that their squad leaders referred to the new

training program in a derogatory fashion. During the end of project review session, Charlie company squad leaders did not hesitate to express their distrust of the tested PT program.

Many factors influence physical fitness, some more than others (Jones 1983). To evaluate these factors simultaneously requires multi-linear regression. Future investigators might consider the following model to evaluate changes in PT programs and physical fitness: Physical Fitness = PT Program + Squad Leader Knowledge + Squad Leader Attitude + Other Tested Internal Factors + Other Tested External Factors.

Conclusion

Following Charlie company's graduation key Sports Medicine, SOI, and Charlie company personnel met to review results and discuss issues and concerns. Decreased injuries and limited duty days represent the program's potential for limiting medical contribution to non-EAS attrition and increasing time available for training. Participants shared concerns, however, regarding the 12 mile hump, the Marine Corps' identified measure of fitness. The most prominent concern appeared to be the risk of sending an "unfit" Marine to the field. Squad leaders indicated that this concern would prevent full program acceptance and assimilation.

Based on this discussion, the Sports Medicine Department revised several aspects of the program. The changes included shortening the Physical Trainer Instructor program, recruiting a senior enlisted Marine, versed in and supportive of the concepts of Sports Medicine, to act as exercise demonstrator, and adding progressive humping to the program. An evaluation of these changes is pending.

Dr. John A. Bergfeld, past President of the American Orthopaedic Society for Sports Medicine, describes Sports medicine as "the application of the knowledge and skills of the medical practitioner to the physically active person, in a proactive, not reactive, fashion"(Bergfeld 1993). Jones, a prolific researcher in the area of exercise related injuries, agrees with Dr. Bergfeld and recommends ongoing studies to describe the nature of sport related injuries and to evaluate strategies designed to prevent them and/or minimize their negative side effects (Jones, Harris, Vinh, and Rubin 1989). This pilot project meets both Bergfeld's and Jones' prerequisites: it is proactive and contributes to existing knowledge on injuries secondary to physical activity.

Maintaining troop readiness remains a high priority in today's military. Injuries, especially those incurred during training, seriously hamper a unit's effectiveness. They not only cause a decrease in readiness, they also burden medical capabilities and training. Injuries are costly. Military leaders, line and medical, must work together to develop methods of enhancing medical readiness. Proposed solutions must be carefully evaluated and changes implemented when indicated. The PT program designed for ITB is scientifically based, demonstrates good outcomes, and appears applicable to both military training and operational environments. The joint effort undertaken between Sports Medicine and SOI has not only produced tangible results for SOI, but has also generated greater interest in a spirit of cooperation in the Camp Lejeune area that will lead to future endeavors to keep troops injury free and readily deployable.

APPENDIX 1: PHYSICAL TRAINING PRE- & POST- TEST

Post-test Sports Medicine Lecture Series

1. Where is the pain of shin splints located?

   a. Knee
   b. Medial (inner) aspect of the distal (lower) tibia
   c. Ankle
   d. Posterior (back) portion of tibia

2. What is a common source of lateral (outside) knee pain?

   a. Shin splints
   b. ACL Tear
   c. Iliotibial band (ITB) tendonitis
   d. PFS

3. What are the 2 most common areas for a stress fracture?

   a. Metatarsals/tibia
   b. Knee/hip
   c. Calf/ankle
   d. Femur/achilles tendon

4. What is the most important treatment for the overuse injuries?

   a Ice
   b. Prevention
   c. Motrin
   d. Immediate return to activity

5. What is the function of the patellofemoral joint?

   a. Extension of the knee
   b. Prevention of ankle sprains
   c. Initiation of heel strike
   d. Prevention of stress fractures

6. What joint in the ankle is important in shock absorption?

   a. Subtalar joint
   b. Calcaneocuboid joint
   c. Calcaneonavicular joint
   d. Mortise

7. What joint has the greatest range of motion given in the anatomy lecture?

   a. Hip
   b. Ankle
   c. Knee
   d. Shoulder

8. What muscle is most important in protecting against PFS?

   a. Vastus medialis obliques (VMO)
   b. Calf
   c. Hamstrings
   d. Hip flexors

9. What structure is important in helping to support the arch?

   a. Mortise
   b. Plantar fascia
   c. Bifurcate ligament
   d. Subtalar joint

10. The hip can be affected by an injury to the foot.
    Circle one: True False

11. What is the first structure to hit the ground during the gait cycle?

    a. Big toe
    b. Arch
    c. Little toe
    d. Heel

12. Which stress fracture site may have the most devastating consequences because of poor blood supply?

    a. Foot
    b. Knee
    c. Hip
    d. Tibia

13. Name the three kcalorie yielding macronutrients and the kcalories per gram that they yield.

    1._____ _____cal/gram

    2._____ _____cal/gram

    3._____ _____cal/gram

14. Name a fourth substance that yields kcalories but does not contribute to energy. List the kcalories per gram.

    1._____ _____cal/gram

15. Which macronutrient does the brain use for energy and is found in the liver, muscle, and the blood?_____

16. The Infantry Marine diet should be made up of what percentage of CHO_____ Choose from the following:

PRO_____	10-15%	55%
FAT_____	20-25%	60%
	30-35%	65-70%

17. Place the letter in the appropriate section of the food guide pyramid and briefly describe which food choices should make up the majority of your troops diet and why.

a. Fruits
b. Breads, cereals, rice, pasta (6-11)
c. Fats, oils and sweets (sparingly)
d. Meats (2-3)
e. Dairy (2-3)
f. Vegetables (3-5)

18. a. Today is your 10 mile hump. You just overheard one of your Marines mention that he feels lethargic (tired), and that he is passing small volume of dark concentrated foul smelling urine. What should you instruct him to do prior to the hump. (Be as specific but brief as possible)

_____

_____

_____

b. After returning form the hump you weigh the Marine. He lost a total of 5 pounds. What should you instruct him to do?

_____

_____

19. a. What is the RDA for protein?_____

b. What is the maximum amount of protein a Marine needs per day?_____

20. One of your Marines has come to you complaining that he is gaining weight now that his activity level has dropped off. He is 21 years old, weighs 175 pounds and his activity level has gone from"heavy" to "very light". Use the formula to give him advice on an appropriate kcalorie level.

Age (18-30): 6.95 X Weight = 679

Activity levels:		
	Very light	1.3
	Light	1.6
	Moderate	1.7
	Heavy	2.1
	Exceptional	2.4

21. One of your Marines is paying $20.00 every 2 weeks to buy the supplement "Hot Stuff" to build muscles and give energy. He is also consuming 1 can of copenhagen per day and smokes nearly half a pack of cigarettes daily. What advice would you give him regarding the use of ergogenic and ergolytic substances?

_____

_____

_____

22. It is the night before a 12 mile road march. The event is scheduled to take 3 hours. One of your Marines asks you to give him advice on the types of foods he should eat the night before so that he has enough energy to carry him through. What types of food examples would you advise him to consume.

_____

_____

23. You have been out in the field for a week. You are marching back to the rear. What would be the best choice for a fluid replacement drink (besides water) based on these choices and why? Orange juice, coca-cola, apple juice, gatorade.

_____

_____

_____

24. List 3 positive psychological effects of regular aerobic exercise._____

_____

_____

25. When confidence is low then_____is usually high.

26. List 3 cognitive (mental) reactions to high anxiety.

_____

_____

_____

27. When anxiety increases there is greater chance for poor performance in what type of activities (list 3)?

_____

_____

_____

28. What is the difference between successful and less successful individuals when they are experiencing anxiety?

_____

_____

Circle the correct answer.

29. T F The proper way to stretch is the ballistic, bouncing type.

30. T F Flexibility is the ability to use muscles and joints through their full range of motion.

31. T F Stretch to the point where pain is felt.

32. T F You should stretch 3-7 days/week.

33. Flexibility is important to:

a. decrease the risk of injury
b. provide relief from muscle tension
c. improve posture
d. all of the above

34. Name three causes of most overuse training injuries.

_____

_____

_____

35. List the three components of fitness.

_____

_____

_____

36. List three elements which describe an exercise program.

_____

_____

_____

37. In planning a safe, progressive exercise program, only_____of the elements can be changes at a time and only by _____%.

38. List at least four characteristics of a good running shoe.

_____

_____

_____

_____

39. After _____ miles, a running shoe has lost _____% of its support capacity and should be replaced.

40. Compared to walking, running one mile places an additional load on the legs of _____.

41. After _____ weeks, 40% of fitness gains are lost.

Circle the correct answer. (7)

42. T F Back injury causes pain and results in lost productivity.

43. T F While lifting you should bendover at the waist keeping your hips held high in the air.

44. T F Sitting is easy on your back.

45. T F While turning with a weight, one should keep their feet still.

46. T F While lifting, the weight should be held close to the body.

47. T F Bending the knees and keeping the back straight while lifting is the best method of preventing back injuries.

48. Name four components of physical fitness:

---

49. What does the term "aerobic" mean?

50. What is the most important muscle in the body?

A. Legs
B. Heart
C. Chest
D. Diaphragm

51. How is oxygen delivered to the muscles? (Circle one)

A. Via the blood
B. Via the central nervous system
C. Via the spinal column.

52. List two training effects on cardiovascular endurance.

APPENDIX 2: PHYSICAL TRAINING COURSE OUTLINE

Participants: Commanding Officer, Executive Officer, Senior Noncommissioned Officers
Site: Marine Corps Base Camp Lejeune, NC School of Infantry
Presentation: Lecture, Overhead Slides, Field Demonstration

Topics

Day 1:	Musculoskeletal Anatomy and Function
	Training Injuries
	Combat Nutrition
	Exercise Physiology
Day 2:	Back Health
	Mind/Body Connection
	Stretching
	Strength Training
Day 3:	Training Protocol
	Final Exam
	Field Demonstration

APPENDIX 3: PHYSICAL TRAINING COURSE BOOKLET OUTLINE

1. Cover: Physical Training Program for the United States Marine Corps
2. Article on Task-Specific Physical Training (Henrie 1991)
3. Introduction
4. Stretches
5. Strength
6. Power
7. Speed
8. The Physical Training Protocol

APPENDIX 4: SUGGESTED INFANTRY TRAINING BATTALION PHYSICAL TRAINING

Training Day 1	Physical Fitness Test
Training Day 4	Company Physical Training
Training Day 5	Company Physical Training
Training Day 7	Obstacle Course
Training Day 9	Hump 6 Miles
Training Day 12	Hump 8 Miles
Training Day 15	Hump 10 Miles
Training Day 19	Company Physical Training
Training Day 20	Company Physical Training
Training Day 23	Company Physical Training
Training Day 24	Company Physical Training
Training Day 29	Hump 12 Miles
Training Day 35	Company Physical Training
Training Day 40	Endurance Course
Training Day 41	Company Physical Training

APPENDIX 5: CHARLIE COMPANY TRAINING SCHEDULE DAY 1 - 17

Components

Warm-up:

Side straddle hops (4 count) X 40

Pre-Stretches with 10 count hold:

Upper Body Resistance (UBR):

Shoulders - behind neck; Shoulders - across chest;
Shoulders - behind back; Flank; Back

Lower Body Resistance (LBR), Run, and/or Hump:

Quadriceps; Calves; Groin; Outer Thigh; Hamstrings;
Foot Dorsiflexors; Flank; Back

Exercises:

UBR Daily Seven:

Double arm curls/ALICE pack (20 repetitions)
Bent-over rows/ALICE pack (25 repetitions)
Supraspinatus flies/canteens (25 repetitions)
Push-ups/flak vest (15 repetitions)
Dead lifts/ALICE pack (20 repetitions)
Shoulder Shrugs/ALICE pack (25 repetitions)
Military Press/ALICE Pack (20 repetitions)
Pull-ups (2 sets of 4 repetitions)

Cool-down:

Wagon wheel walking routine, 3-5 minutes

Training Day (T-) Schedule

1: Run on easy, 15 minutes in utilities and sneakers
2: UBR, 1 set in boots and utilities (utes)
3: Run on easy, 15 minutes and 1 set LBR in PT gear
4: Warm-up and stretch in PT gear
5: 1 set UBR in boots and utes
6: 1 set LBR and 20 minute hump in boots and utes
7: 1 set UBR and 20 minute hump in boots and utes
8: 1 set LBR and 20 minute hump in boots and utes
9: 1 set UBR and 20 minute hump in boots and utes
10: LBR, 1 set in PT gear
11: 1 set UBR and run on easy 19 minutes in PT gear
12: 1 set LBR in boots and utes
13: 1 set UBR and 22 minute hump in boots and utes
14: 1 set LBR and run on easy 19 minutes in PT gear
15: 1 set LBR and 24 minute hump in boots in utes
16: 2 sets UBR and 24 minute hump in boots and utes
17: 2 sets LBR and 24 minute hump in boots and utes

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